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XI. *Observations made at Beverly, Lat. $42^{\circ} 36' N.$ Long. $70^{\circ} 45' W.$ to determine the Variation of the magnetical Needle. By the Rev. JOSEPH WILLARD, President of the University at Cambridge, V. Prof. A. A.*

AN attention to the variation of the magnetical needle, it is well known, is of great importance at sea, nor is it of small consequence upon the land ; especially in *North-America*. From the first settlement of this country, the lines between towns, and between lots of land appropriated to individuals, have been determined by the magnetical needle. If the variation always continued the same, no difficulty would ensue, in again tracing the lines, upon the same magnetical course ; but as it alters from time to time, the lines run in any succeeding years must deviate from the first, and from one another, unless proper allowances are made for the alteration.

From the want of a sufficient number of observations, and of attention to this subject, in those who have surveyed the lands in this country, difficulties have arisen at one time and another, between towns and individuals. To remedy this inconvenience for the future, this Academy, some time ago, recommended magnetical observations, to determine the variation, which it is to be hoped will be made in various parts of the country, and at proper intervals of time, and be uniformly attended to by our surveyors. Since this recommendation, I have endeavoured to determine the variation at *Beverly*, with as much exactness as I was able. With this view, I procured an azimuth compass, of Dr. *Gowin Knight's* invention. It appears to be good

good of its kind, and is furnished with a vernier, pointing out the azimuth to $5'$; but the eye may pretty easily determine by it to $2'$, and sometimes to $1'$. To observe by this compass, I ascertained the going of my clock to great exactness, and on five different days, took several magnetical azimuths, both before and after the sun passed the meridian, and noted the moments, which I have put down in apparent time. For these times, I have calculated the true azimuths by spheric trigonometry, and have carried out the variation for each observation separately. On two days, I also determined the variation, by taking magnetic azimuths, at corresponding altitudes of the sun, making proper allowances for the change of declination, between the observations of the forenoon and afternoon. On each of the days, some of the observations differ several minutes from others; but this I cannot attribute to want of attention, as I am conscious that I made them with all the care in my power. The differences, I suspect, principally arose from the difficulty of determining, with entire exactness, when the shadow from the hair was on the line beneath; and when in two observations, the error should be on different sides, the sum might make a number of minutes. But I have the satisfaction of finding the mean results for the several days well agreeing with each other, which is a good evidence that the result of the whole must be, at least, very near the truth.

These observations and deductions are now humbly submitted to the Academy, with wishes that they may subserve the designed purpose.

320 *President WILLARD's magnetical Observations,*

JULY 27, 1781.

Ap. times of obf.	Sun's mag. az. per obf.	Sun's true az. per cal.	Varia. of the need.
11 ^b 34'	S 8° 2' E	S 15° 9' E	7° 7 W.
11 36	7 0	14 2	7 2
11 50	S 1 10 W	5 57	7 7
11 58	5 55	1 15	7 10
12 4	9 28	S 2 26 W	7 2
12 20	18 45	11 45	7 0
12 26	22 15	15 10	7 5
12 28	23 30	16 17	7 13

Variation of the needle by a mean of 8 observations, July 27. 7 5 $\frac{1}{2}$

JULY 28.

11 ^b 44	S 2° 25' E	S 9° 19' E	6° 54' W.
12 4	S 9 15 W	S 2 20 W	6 55
12 6	10 35	3 30	7 5
12 8	11 45	4 40	7 5
12 22	19 45	12 46	6 59
12 26	22 5	15 2	7 3
12 30	24 15	17 16	6 59

Variation by the mean of 7 observations, of July 28. 7 0

JULY 30.

11 52	S 2 30 W	S 4 37 E	7 7 W.
12 2	8 15	S 1 10 W	7 5
12 6	10 28	3 28	7 0
12 18	17 28	10 19	7 9
12 26	21 55	14 47	7 8

Variation by the mean of 5 observations, of July 30. 7 5 $\frac{1}{2}$

JULY 31.

11 29 32"	S 10 10 E	S 17 7 E	6 57 W.
11 39 32	4 35	11 37	7 2
11 43 32	2 20	9 23	7 3
11 51 32	S 2 5 W	4 51	6 56
11 55 32	4 32	2 34	7 6
11 59 32	6 40	0 16	6 56
12 1 32	7 50	0 53 W	6 57

Variation by the mean of 7 observations, of July 31, 6 59 $\frac{1}{2}$

AUGUST 1.

11 53 52	S 3 32 W	S 3 28 E	7 0 W.
11 59 52	7 2	0 4	7 6
12 1 52	8 0	1 4 W	6 56
12 3 52	9 10	2 12	6 58
12 15 52	15 58	8 59	6 59

Variation by the mean of 5 observations, of August 1, 6 59 $\frac{1}{2}$
Variation

Variations determined by magnetic azimuths, taken at equal altitudes of the sun, forenoon and afternoon.

AUGUST 6.

A. M.	P. M.	Difference.	$\frac{1}{2}$ Diff. = Variation.
68° 28'	82° 30'	14° 2'	7° 1' W.
65 30	79 20	13 50	6 55
63 50	77 35	13 45	6 52 $\frac{1}{2}$
63 30	77 15	13 45	6 52 $\frac{1}{2}$
63 0	77 0	14 0	7 0
62 30	76 32	14 2	7 1

Mean variation by the above six observations of August 6,
Equation for change of declination,

6 57
+ 4

Variation,

7 1

AUGUST 15.

67 30	81 30	14 0	7 0
67 10	81 5	13 55	6 57 $\frac{1}{2}$
66 42	80 40	13 58	6 59
66 15	80 18	14 3	7 1 $\frac{1}{2}$
66 2	79 55	13 53	6 56 $\frac{1}{2}$
64 45	78 40	13 55	6 57 $\frac{1}{2}$
64 12	78 8	13 56	6 58
63 58	77 48	13 50	6 55
63 37	77 35	13 58	6 59
63 0	77 6	14 6	7 3
61 46	75 45	13 59	6 59 $\frac{1}{2}$
61 20	75 26	14 6	7 3
60 58	74 50	13 52	6 56
58 50	72 45	13 55	6 57 $\frac{1}{2}$
58 30	72 25	13 55	6 57 $\frac{1}{2}$
58 15	72 10	13 55	6 57 $\frac{1}{2}$
57 40	71 30	13 50	6 55
57 10	70 58	13 48	6 54
56 43	70 42	13 59	6 59 $\frac{1}{2}$

Mean variation by the above nineteen observations,
Equation for change of declination,

6 58 $\frac{1}{4}$
+ 5

Variation by nineteen observations of August 15,

Ditto	fix	6,	7 3 $\frac{1}{4}$
Ditto	five	1,	7 1
Ditto	seven	July 31,	6 59 $\frac{1}{2}$
Ditto	five	30,	6 59 $\frac{1}{2}$
Ditto	seven	28,	7 5 $\frac{1}{2}$
Ditto	eight	27,	7 0
			7 5 $\frac{3}{4}$

Varian. by the mean of seven days, containing fifty-seven obs. 7 2